Washington State University

Final Technical Report on NAG 5-1075
Winds from Planetary Nebula Nuclei

Principal Investigator: Julie Lutz
Co-Investigators: James Kaler and Catherine Imhoff

Report Covers Period from October 1, 1988 to March 31, 1989

The purpose of this research project is to combine optical and IUE data on a sample of planetary nebula central stars to derive the physical characteristics of these objects. Dr. C. L. Imhoff obtained the IUE spectra and did the calibrations. Dr. J. B. Kaler is working with the majority of the spectra. Dr. J. H. Lutz concentrated on analysis of the data from He 2-36, He 2-99 and He 2-104.

Lutz obtained new optical images and spectra for He 2-36. The most significant result from the new IUE spectra is that there is no evidence for the C IV "jet" reported by Feibelman. We have concluded from re-analysis of the previous He 2-36 IUE data that the reported feature must have been a cosmic ray event. The "jet" did not show up in the optical images. The IUE and optical data were combined to determine temperatures, densities and chemical compositions for the nebula of He 2-36 and some of the properties of the binary central star. A paper was presented at the Washington, D.C. AAS meeting on the results of these new data. A detailed paper on all the observations of He 2-36 is being written for publication in the Publications of the Astronomical Society of the Pacific.

The IUE and optical work on He 2-104 resulted in the conclusion that this is a rare object caught in transition between the symbiotic star and planetary nebula phases of evolution. Two papers resulted from the studies, and considerable popular attention (Sky and Telescope, Science News, Science, etc.) was given to this object during 1989.

Work is still progressing on He 2-99. One paper was published, but recent observations are still being analyzed. J. Lutz was able to obtain high resolution echelle spectra of He 2-99 with the 4-m telescope at Cerro Tololo Interamerican Observatory. These detailed optical spectra are being combined with the new IUE spectra (which have much better signal/noise than the spectra available previously) to produce a line atlas for this complicated WR central star.

The papers that have appeared so far as a result of the grant research are as follows:

- "A Case Study of a WC Planetary Nebula Nucleus: Henize 2-99", J. B. Kaler, R. A. Shaw, W. A. Feibelman, and J. H. Lutz, Astrophys. J. Suppl., 70, 213 (1989).
- "He 2-104: A Symbiotic Proto-Planetary Nebula?", H. E. Schwarz, C. Aspin and J. H. Lutz, Astrophys. J. letters, 344, L29 (1989).

- "He 2-104: A Link Between Symbiotic Stars and Planetary Nebulae?", J. H. Lutz, J. B. Kaler, R. A. Shaw, H. E. Schwarz, and C. Aspin, Publ. of the Astr. Soc. Pacific, 101, 966 (1989).

The following paper is in preparation and will be submitted to the Publications of the Astronomical Society of the Pacific later this spring.

- "Ultraviolet and Optical Studies of He 2-36", J. H. Lutz, J. B. Kaler, R. A. Shaw, C. L. Imhoff, S. Heathcote and W. Weller (1990).

In addition, the following talks were presented based in part upon the IUE observations during the grant period:

- "He 2-104: Object in Transition between Symbiotic Star and Planetary Nebula?", 174th meeting of the American Astronomical Society, 1989.
- "New Ultraviolet and Optical Observations of He 2-36", (with J. B. Kaler, R. A. Shaw, C. L. Imhoff, S. Heathcote and W. Weller), 175th meeting of the American Astronomical Society, 1990.